Ad Hoc Meteorological Modeling Group:
August 2001 Meeting Summary

ATTENDEES:

Pat Dolwick, Brian Orndorff, Norm Possiel (USEPA, OAQPS)

Devin Dean (U.S. Air Force)

Joe Vaughan (Washington State University)

Kemal Gurer (California EPA, ARB)

Satoru Mitsutomi (South Coast AQMD)

Brenda Johnson (USEPA, Region 4)

Kurt Kebschull (Connecticut DEP)

Kevin Doty (University of Alabama at Huntsville, NSSTC)

Xin Qin (RWDI, Inc.)

Qi Mao (Tennessee Valley Authority)

Ken Anderson (Ameren)

Bret Anderson (Nebraska DEQ)

Steven King (Illinois EPA)

Matthew Johnson (Iowa DNR)

Avi Lacser, Tanya Otte (USEPA, ORD)

Lara Reynolds (DynTel Corp.)

Chris Arrington (West Virginia DEP)

Jesse Bash, Pat Bresnahan (University of Connecticut)

Michael Ku (New York DEC)

Jennifer Galbraith (New Hampshire DES)

Craig Tremback (Mission Research Corp.)

Don Olerud, Aijun Xiu (MCNC)

Mike Abraczinskas, George Bridgers (North Carolina DENR)

Kirk Baker (LADCO)

Chris Emery (Environ)

INTRODUCTION:

The session was started with some background information from Pat Dolwick. A short review of the history of the AHMMG, including the 2000 meeting, was provided. Because of a large number of volunteer speakers, this year's meeting was expected to feature more presentations than the roundtable discussions that anchored the 2000 AHHMG sessions. It was noted that the future of the various "ad hoc" modeling groups is uncertain given the heavy workloads of the RPO staffs. EPA is interested in increasing/maintaining the current level of interaction between members of the meteorological/AQ modeling community. EPA views these meetings as useful companions to annual

MM5 and RAMS user workshops which typically do not consider air quality driven meteorological analyses in great detail.

SUMMARIES/RESULTS OF ONGOING METEOROLOGICAL MODELING EXERCISES:

IOWA DNR: Matthew Johnson presented preliminary results from a series of MM5 sensitivity runs meant to assess the impacts of differing meteorological configurations on eventual CMAQ model output. The goal is to produce several viable meteorological input datasets that can be used to generate and evaluate CMAQ simulations over the eastern U.S. A high ozone episode in July 1999 was chosen as an initial modeling period. The MM5 modeling is using a 36km horizontal resolution and 27 sigma levels in the vertical. A base configuration was identified using KF cumulus parameterization, an MRF mixing scheme, cloud radiation, simple ice, the 5-layer soil model, and default FDDA. The plans are to assess the model runs subjectively (RIP, Vis5d) and objectively (MAPS, v2.9). The base case simulation is complete and appears to be suitable for sensitivity testing, although there are concerns about wind direction errors in the outer periods (e.g., 120 hours). Some of the physics options that are planned to be individually tested include: the Anthes-Kuo and Betts-Miller cumulus parameterization schemes; the Blackadar, ETA, and Gayno-Seaman PBL schemes; and the OSU/ETA land surface model. Further testing may investigate differing vertical layer structures and using the reanalysis fields for initialization. Iowa DNR has experienced both hardware failures and system upgrades which have somewhat slowed the pace of the project. In conclusion, it was noted that an optimal configuration of physics options may not be possible in all regions.

For more information, e-mail: matthew.johnson@dnr.state.ia.us.

MCNC: Don Olerud discussed a series of MM5, version 3.3 and 3.4, sensitivity analyses that are being completed at various horizontal resolutions (36/12/4) for a 1997 eastern U.S. ozone episode. A detailed summary of the base case and the diagnostic modeling completed to date is available online at http://envpro.ncsc.org/NCDAQ/Met/97i. The main problem in the 1997 base case were the mixing ratios (model was too dry) and the afternoon surface temperatures (model drops off too quickly). MCNC has also tested the Pleim-Xiu land surface model for this episode. The temperature still peaks too early and then drops off too quickly (even more so than with Blackadar). There is more convection in the P-X case (not consistent with the observations) and generally the P-X/ACM selection results in much lower PBL heights. It was cautioned that the soil moisture inputs are still pretty rudimentary.

For more information, e-mail: olerud@mcnc.org.

RWDI: Xin Qiu discussed the sensitivity modeling that has been completed over a southern Ontario domain for a period during July 1999. The testing has been conducted with 108, 36, 12, and 4 km horizontal resolutions. This episode featured relatively high ozone over the Hamilton region (90-100

ppb). Some of the earliest CMAQ runs indicated a tendency to severely underestimate daytime ozone values. It was determined that the problem was resulting from the cloud fields predicted by MM5. Several combinations of cumulus parameterization and explicit moisture schemes were tested. The optimal configurations were resolution-dependent. At 12km, the K-F plus simple ice combination generated considerably fewer clouds and ultimately yielded 10-15 ppb more ozone in the CMAQ base case (more closely aligned with the observations).

For more information, e-mail: xq@rwdi.com.

NYDEC/CDEP/NHDES: Several presenters reviewed the evaluation of the 1997 MM5 modeling conducted over the northeastern U.S. by the University of Maryland. Michael Ku focused on two sites: Brookhaven National Laboratory and Millstone CT and via time series plots concluded that the temperatures (2-4 degrees C, especially during the day) and wind speeds were generally overpredicted in the model. Kurt Kebschull looked at three separate sites and concluded that wind speeds and directions were often associated with errors of up to 5 m/s and 30 degrees, respectively. There was some concern, however, that one of the sites may have been unduly influenced by local terrain effects. Jennifer Galbraith focused an evaluation on three sites in New Hampshire. Several deficiencies were identified in the modeling, including: absence of a significant sea breeze, diurnal patterns of wind speed, and wind directions in general.

For more information, e-mail: mku@air.dec.state.ny.us, kurt.kebschull@po.state.ct.us, jgalbraith@des.state.nh.us.

Environ: Chris Emery summarized on-going evaluation activities being completed on behalf of TNRCC. The goal is to develop a quantitative assessment capability for meteorological modeling activities analogous to those already available for air quality modeling. These objective criteria could then be used to a) assess the level of confidence in the meteorological modeling, and b) compare/contrast with other MM5/RAMS modeling exercises. Approximately two dozen studies were analyzed to determine the statistical behavior (bias, error, RMSE, index of agreement, correlation) of the models with regard to certain parameters (winds, temperature, humidity, etc.). TNRCC, in conjunction with Environ, may soon be proposing benchmarks that can be used to identify appropriate model expectations. Chris listed several caveats (highly generalized comparisons, daily/hourly variations can be important, effects of FDDA, etc.), but overall the concept is expected to have some merit. Additionally, Environ has also completed some MM5 modeling for the "near non-attainment areas" in Texas. Some of the results from this modeling were briefly discussed.

For more information, e-mail: cemery@environcorp.com.

LADCO: Kirk Baker discuss meteorological modeling plans at LADCO and the Midwest RPO. Several MM5 simulations are planned to support practice PM/Haze modeling: June 1995, July 1998, and January 2000. Several sensitivity runs will likely be completed focusing on various PBL schemes

and multiple analysis fields. The majority of the presentation, however, was dedicated to comparing different sources of photo synthetically activated radiation (PAR) data, which is a key component in the estimation of biogenic VOC emissions. Four different sources of PAR data were compared: CMAQ/MCIP, BEIS2, satellite-estimated data, and MM5/CCTM2 (in order from highest to lowest PAR). One of the primary conclusions was that the CMAQ/MCIP and BEIS2 methods overestimated PAR and should not be used. Ozone modeling results show as much as a 10-15 ppb difference between the BEIS2 PAR inputs and the satellite-derived PAR data.

For more information, e-mail: baker@ladco.org.

EPA, Office of Research and Development: Tanya Otte discussed the status of version 2 of MCIP, which is the primary interface between MM5 and CMAQ. For version 2, the code has been completely re-engineered with: free-form F90, dynamically allocatable grids, and runtime user definitions. The new MCIP will read data from both MM5 versions 2.x and 3.x. There will be "pass-thru" options for PBL (Blackadar initially), as opposed to the recalculation of PBL which currently occurs. It will support the P-X land surface model, output additional needed data (snow, ice, soil moisture, etc.), and can read multiple MM5 files as input. The primary remaining limitation is that the new MCIP will only output dominant land use categories. The architecture will be entirely serial and will run on SUN, IBM, CRAY, Linux, and NT machines. The updated preprocessor is expected to be available in November 2001 and ORD is interested in enlisting beta-testers for the code. Tanya also briefly discussed a problematic case in which ETA data were used to initialize MM5 for a 1998 episode.

For more information, e-mail: otte.tanya@epa.gov.

University of Alabama at Huntsville: Kevin Doty presented results from three of the nine RAMS modeling applications completed as part of the Southern Appalachian Mountain Initiative (SAMI). UAH completed six of the RAMS, version 3a, simulations on a 2-cpu DEC-Alpha workstation. The model runs used a horizontal resolution of 96, 24, and 12km with 35 vertical layers (17 layers in the lowest 3 km). In some (winter) cases, UAH believes this resolution may have been too coarse. The simulations included the full suite of RAMS microphysics, with cloud water and rain water only. Convective inhibition was added to the Kuo convective parameterization and surface nudging was used to control surface fluxes of heat/moisture (not over the Appalachians, however). Initializing soil moisture was problematic. Spatial maps of temperature, mixing ratio, and wind speed/direction bias and root mean square error were shown for three episodes: July 1995, May 1995, and February 1994. Additionally, time series plots comparing model/measured parameters were shown. Finally, tables of episodic-average statistics were displayed. Temperature biases were all within 1.5 degrees C. The RAMS output generally underestimated moisture and overestimated wind speed. While there were problems with (convective) precipitation estimates and the interactions between clouds and radiation, the modeling was generally on par with operational forecasts, in terms of equitable threat scores.

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For more information, e-mail: kevin.doty@nsstc.uah.edu.

Tennessee Valley Authority: Qi Mao presented some preliminary results from an MM5 modeling project that is being completed in conjunction with UAH and EPA/ORD. The plan is to investigate model performance and complete a series of sensitivity tests at 32, 8, 2 km resolutions over the Nashville TN area for the period 6/15 to 7/15/99. The 32 and 8km base case simulations are completed. TVA has also completed a series of sensitivity runs looking at multiple layers below sigma = 0.995. For this particular episode/domain, it did not appear that a more highly resolved surface layer yielded any better model performance.

For more information, e-mail: qmao@tva.gov.

MCNC: John McHenry gave a brief overview of some of the real-time air quality forecasting being completed this summer over the eastern U.S. Ozone forecasts are currently being generated for periods out to 48 hours as part of a joint effort between MCNC, NOAA, NC-DENR, TNRCC, and EPA. A combination of MM5, SMOKE, and MAQSIP are being used to generate twice-daily forecasts for several different domains and horizontal grid resolutions (45, 15, and 5km).

For more information, e-mail: mchenry@mcnc.org.

Washington State University: Joe Vaughan provided an update on a real-time air quality dissemination and forecasting program being utilized in the Pacific Northwest, the Air Indicator Report for Public Awareness and Community Tracking (AIRPACT). This modeling exercise uses MM5, CALMET, and CALGRID to generate 24 hour ozone forecasts over 36, 12, and 4km resolution grids. The work is being done in conjunction with EPA - Region 10, the University of Washington, the Puget Sound Clean Air Authority, and the Washington Department of Ecology. Several limitations of the modeling were noted, the primary one being the lack of PM forecasts which are more needed in the Pacific Northwest than their ozone counterparts. WSU is hopeful that they will be able to transition to CMAQ in the near future to facilitate such predictions.

For more information, e-mail: jvaughan@wsu.edu.

EPA, Office of Research and Development: Avi Lacser discussed progress made toward implementing an urban canopy parameterization in MM5. Radiation, turbulence, windfields, and canopy heating are all different in a densely urban setting. Parameterizations to account for dynamics (drag of the buildings) and thermodynamics (heat equation is used) have been developed. Some 1.3 km MM5 modeling has been completed for a domain over Philadelphia PA. The results indicate that differences of 1-2 m/s in wind speed are not uncommon over the urbanized areas when the canopy parameterization is utilized. More validation work is planned in the future, as well as the refinement of better input data sets (e.g., land use), and more detailed physical routines (including an improved land surface model).

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For more information, e-mail: avl@hpcc.epa.gov.

MCNC: Aijun Xiu provided an update on the Pleim-Xiu land surface model (LSM) recently added to MM5. This LSM was designed to provide an improved model response to soil moisture and vegetative conditions, as well as a better partition of surface energy. The model breaks the surface into two regions: the surface (1 cm) and the root zone (1 m). P-X contains three soil moisture options and three vegetation growth options. Several evaluations of the P-X LSM are in the literature. MM5 PBL predictions were compared against Nashville 1999 field study data. Additionally, Aijun discussed a regional-scale integrated meteorological atmospheric chemistry model. A model integrating MAQSIP and MM5 has been developed and applied for the July 1995 case at a resolution of 36km. Time series plots of downward shortwave radiation and sensible heat flux were shown. The model appeared to reasonably capture the spatial differences in aerosols for this case.

For more information, e-mail: aijun@ncsc.org.

DISCUSSION OF INDIVIDUAL METEOROLOGICAL MODELING ISSUES:

Status of Weather Research and Forecast (WRF) Model: Ken Schere provided a brief update on the WRF model. This meteorological model is designed for both research and operational needs. It is being developed primarily by NCAR, NOAA, the University of Oklahoma, the Air Force Weather Agency; with additional collaboration from NASA, EPA, and the academic community. There was a beta release last year. A research version is expected to be released later in the year, while the goal remains to complete the operational version by the end of 2004. From the perspective of the air quality modeling community, several potential issues were listed: 1) there are no plans for an FDDA option, 2) some physics options presently in MM5 may not be ported over to WRF, and 3) the chemistry coupling is expected to be mostly online (as opposed to offline, which may be more appropriate for air quality modeling purposes). For more information, see http://www.wrf-model.org.

Status of RAMS Model: Craig Tremback provided a broad description of the past, present, and future of the Regional Atmospheric Modeling System (RAMS). The current version of the model is version 4.3. Version 5.0 should be available by the end of the year. A large variety of groups are currently employing RAMS for their meteorological modeling analyses including, but not limited to, NASA, DTRA, NOAA, several groups that issue electrical load forecasts, and operational meteorological forecasters in Brazil. Results of a MM5/RAMS comparison in the Houston region for a September 1993 episode were presented. For this particular application, RAMS tended to generate more accurate replications of the Gulf breeze and wind patterns in general. In the future, the developers of RAMS plan to add an urban canopy layer as well as the capability to model globally, among other enhancements.

Discussion of RPO meteorological modeling plans: The CENRAP modeling states are planning

on modeling a full year of meteorology (likely 1999) using MM5. The staff and computing resources are available, but assistance may be needed on the evaluation of the meteorological modeling results. Additionally, CENRAP plans for a REMSAD jumpstart exercise that may use EPA's 1996 MM5 data and NESTDOWN to generate 12km meteorological data over the central U.S. There was a short discussion as to how map projection choices would influence meteorological modeling results. The general consensus seemed to have been that differing selections as to central meridians and true parallels (in a Lambert projection) can result in different meteorological output, particularly in areas with sharp topographical gradients. However, there appear to be no known reasons to expect one set of projection characteristics to result in more accurate fields than any other projection definition, within the bounds of the maps discussed to date by the RPOs.

WRAP is also in the process of preparing a full year of data for the western 2/3 of the U.S. Configuration choices for this modeling are currently being considered. The Midwest RPO is planning to apply MM5 to episodes within June 1995, July 1998, and January 2000 for preliminary PM/Haze AQ modeling. Several sensitivity runs will likely be completed focusing on various PBL schemes and multiple analysis fields. VISTAS is starting to think about meteorological modeling issues such as: a) the need for consistent protocols, b) annual vs. episodic modeling needs, c) years to model, and d) evaluating model performance. MANE-VU just formed in July 2001 and the technical discussions regarding meteorological modeling are just underway.

EPA noted that they are planning several meteorological modeling activities over the next year. Likely analyses include: a) an annual MM5 simulation for the year 2000 at a 36km resolution, b) episodic MM5 modeling at 12km resolution for certain high ozone periods in 1999 and 2000, c) sensitivity testing on both of the above projects, d) an assessment of the feasibility of using archived meteorological data sets (RUC, ETA, NCAR MM5, etc.) to drive coarse-scale air quality modeling analyses, and e) an evaluation of all of the above data sets, as well as a review of meteorological model performance evaluation methodology.

Model Performance Evaluation: There was a general agreement that the performance benchmarks being developed by TNRCC/Environ would be a useful tool for evaluating internal improvements. Several participants recommended against using statistics of this sort as rigorous criteria for model acceptability. It was noted that the NCEP web page has several links discussing operational meteorological model performance.

Computing Platforms and Analysis Software: Based on a show of hands, it appeared that the AHHMG participants were about evenly divided between those that are completing the meteorological modeling simulations on Linux clusters versus those that are using UNIX workstations. There was a short discussion of the pros (faster, cheaper) and cons (durability, network issues) of Linux clusters as well as a discussion as to the optimal number of nodes. There seems to be no dominant piece of analysis software that a majority of groups have used to analyze the results of their MM5/RAMS runs. MAPS may have been the most frequently cited tool, but several other available and "homegrown"

tools were also mentioned. There appeared to be a community need for a tool that could rapidly convert various observations to a common data format.

Data Archival and Transfer: One participant used the phrase "sinking in a sea of data" to describe the issue of archiving the large quantities of data generated in a meteorological modeling exercise. Some groups mentioned success with buying plug and play hard drives which can be shelved and mailed, as necessary. Others had found firewire drives to be useful for intermediate storage. Further complicating matters is the need for data redundancy in the case of a hardware failure. Overall, problems appeared to far outpace solutions when it comes to data backup and transfer.

Grid Resolution: There was a brief discussion about the horizontal resolution scales for which cumulus parameterization breaks down. While some groups have run Grell (MM5) and a modified Kuo (RAMS) scheme at scales of 2-4 km, they have had to make modifications to the trigger functions. Otherwise, "grid point storms" dominate the wind flow patterns.

FUTURE OF THE AD HOC METEOROLOGICAL MODELING GROUP:

The immediate feedback from the group was that the meeting was generally a productive usage of people's time. There were suggestions to structure subsequent meetings to be more issue oriented. Additionally, suggestions were made as to additional groups that should be extended an invitation to future meetings. More feedback will be solicited through the metgroup@ncsc.org listserv.

There was an appeal, from the current chair, for volunteers for either new AHMMG leadership or someone willing to share the organizational responsibilities. A set of meeting notes will be written and transmitted via the listserv. The listserv will be updated to reflect new participants. It is expected that another meteorological modeling workshop will be held again next year, likely in the August time frame.